AN ETHNOBOTANICAL ACCOUNT OF THE VEGETATION COMMUNITIES OF THE WOLA REGION, SOUTHERN HIGHLANDS PROVINCE, PAPUA NEW GUINEA

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ABSTRACT.—The vegetation communities distinguished by the Wola people of the Southern Highlands Province of Papua New Guinea are the subject of this paper, which complements a previous one on their botanical taxonomic scheme (*Journal of Ethnobiology* 15:201-235). The Wola identify nine vegetation types, with a further four sub-types, ranging from climax montane forest to seral communities of grassland. The composition of these communities is investigated, supported by data on plant species present, collected in a series of quadrat surveys (detailed in Appendix). The number of species in each community is found to range from 18 to 174. The Wola describe the vegetational communities on disturbed land as comprising an anthropogenic series of varying composition and species richness that is compared to the unaltered forest community. This paper is organized around this presumed ecological succession. While there is a broad correspondence between the local and scientific recognition of these ecological zones, which the quantitative data reinforce, the differences in these knowledge traditions should not be overlooked. Wola perceptions are outlined so far as apprehensible. Attitudes to human induced changes in vegetation cover are also explored, and found to be equivocal.

RESUMEN. — Las comunidades vegetacionales distinguidas por la gente wola de la Provincia de las Tierras Altas del Sur en Papúa Nueva Guinea son el tema de este trabajo, que complementa un artículo previo acerca de su esquema taxonómico botánico (*Journal of Ethnobiology* 15:201-235). Los wola identifican nueve tipos de vegetación, con cuatro subtipos adicionales, que van desde bosque clímax de montaña hasta comunidades secundarias de pastizal. Investigamos la composición de estas comunidades, con el apoyo de datos acerca de las especies de plantas presentes, recabados en una serie de encuestas de cuadrante. Encontramos que la composición de especies en las comunidades varía de 18 a 174. Los wola hablan de las comunidades vegetacionales establecidas en tierras perturbadas abarcando una serie antropogénica de variable composición y riqueza de especies que se relaciona con la comunidad de bosque no alterado, y nuestro trabajo está organizado alrededor de esta supuesta sucesión ecológica. Si bien a grandes rasgos hay una correspondencia entre la identificación local y la identificación científica de estas zonas ecológicas, que es reforzada por los datos cuantitativos, no deben dejarse a un lado las diferencias entre estas tradiciones de conocimiento, y esbozamos las percepciones wola en la medida que son aprehensibles. Exploramos también las actitudes hacia los cambios en la cubierta vegetal inducidos por los seres humanos, y encontramos que son equívocas.

RÉSUMÉ. — Cet article traite des zones de végétation distinguées par les Wola, un peuple habitant les Southern Highlands de la Papouasie-Nouvelle-Guinée. Il complète un article précédent sur le système classificatoire wola des plantes (*Journal of Ethnobiology* 15:201-235). Les Wola identifient neuf types de végétation, plus quatre autre sous-types, en partant de la zone forestière montagneuse climacique jusqu'aux zones sérielles herbacées. La composition de ces zones est examinée avec des données sur les espèces végétales présentes inventoriées au moyen d'une série de levés de terrain par lots circonscrits (détails en annexe). Le nombre d'espèces dans les zones varie de 18 à 174. Les Wola parlent des zones de végétation sur les terres perturbées comme étant constituées d'une série anthropogénique de composition variée et très riche en espèces qu'on rapporte à la zone forestière non modifiée et nous avons organisé notre article conformément à cette succession écologique présumée. Bien qu'il y ait une correspondance générale entre l'identification locale et l'identification scientifique de ces zones écologiques, ce que les données quantitatives viennent appuyer, les différences entre ces traditions de connaissances ne doivent pas être négligées et les perceptions des Wola sont mises en évidence en autant qu'elles ont pu être dévoilées. Les attitudes à l'égard des changements du couvert végétal d'origine humaine sont aussi examinées et apparaissent équivoques.

The indigenous classification of biological communities has so far received considerably less attention than folk systematics. The understanding that people like the Wola of the Papua New Guinea highlands have of their plant resources predictably extends well beyond naming the flora that occurs in their region, and then ordering these plants according to their folk botanical classification. It is necessary to go beyond a discussion of taxonomic schemes, interesting as these are, to explore more fully people's understanding of plant associations and ecology — which they achieve in part using their classifications — in order to achieve a fuller understanding of their perceptions of their natural environment and how these inform their interactions with it. In a previous paper (Sillitoe 1995a) I made a start in cataloguing the plants that occur in the Wola area and describing how Wola classify them. This is the first step towards an appreciation of their knowledge of their region's vegetation and their relation with and influence upon it.

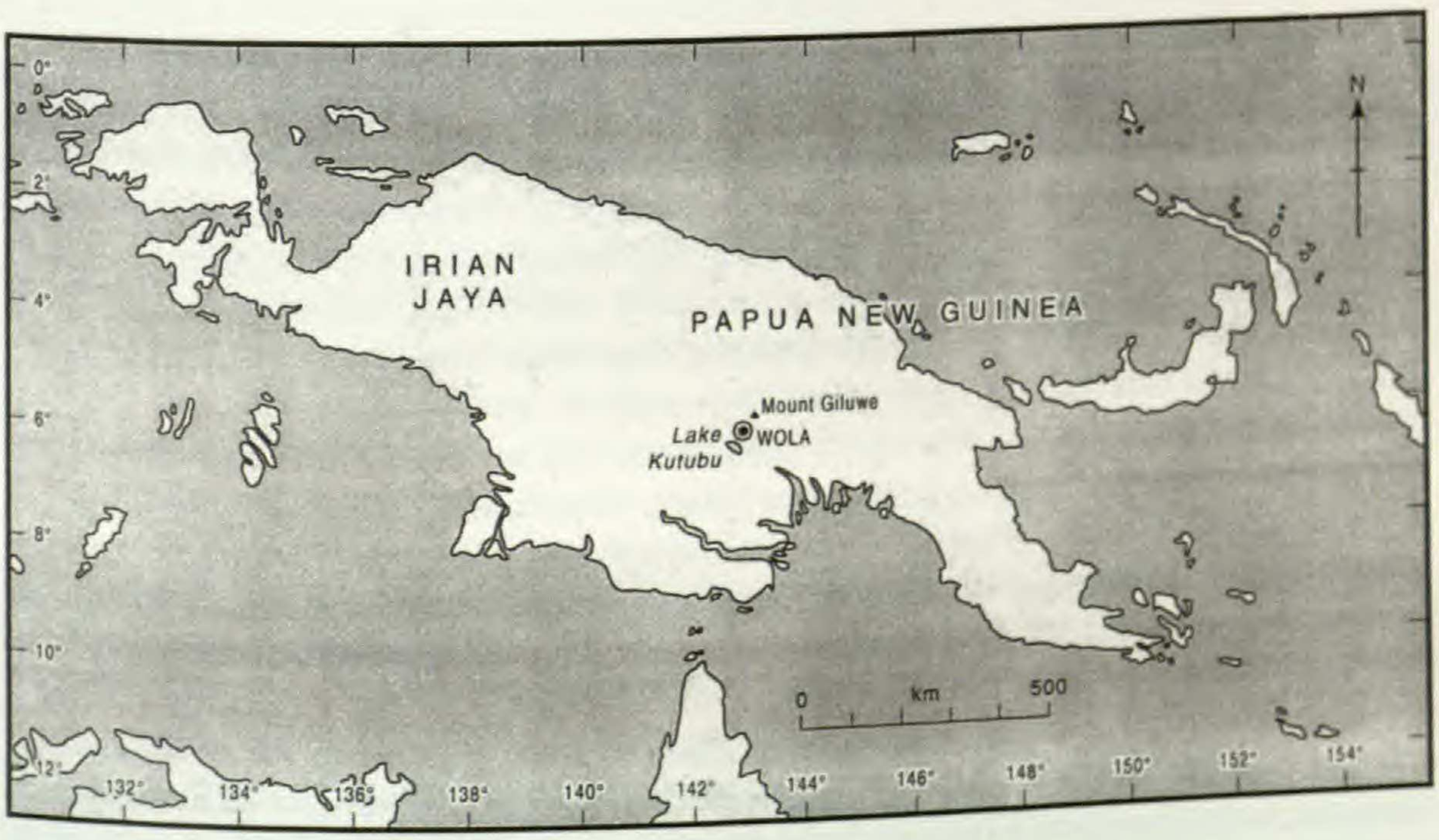
The next step involves documenting the different plant communities and habitats recognized by the Wola. To that end, I investigate here the composition and structure of these associations. (For further information on the various vegetational communities described here, and a finer botanical classification of the different communities, see Robbins and Pullen 1965; Paijmans 1976:84-97; Johns 1976, 1982). The Wola recognize several different vegetational communities, comprising varying populations of plants and animals, both named and unnamed. Their awareness of these communities and understanding of their dynamics influence their attempts to manage their natural resources and their consequent impact upon the environment. This knowledge informs their cultivation strategies, although it is more evident in their practices than in their verbalized accounts. This presents certain epistemological problems in documenting their appreciation of the mark they make on the plant world (Sillitoe 1995b).

The taxonomic schemes of people only reflect part of their understanding of the natural world. Environmental knowledge is transferred between generations, in other ways too, such as in terms of vegetation communities. This information among Highlanders is not codified but diffuse, communicated piecemeal through experience, and has a marked practical aspect. When asked to justify their naming of a vegetation community they are likely to look perplexed. They are not used to being asked how they distinguish these communities, and do not readily cite, for example, certain plants in specified proportions as diagnostic. Their awareness of vegetation community structure has accumulated over years of experience, of seeing these communities and hearing comments from others about them. Placing indigenous and scientific perspectives of vegetation ecology side by side helps us to achieve a more rounded understanding of the environmental impact of human activities, relating both to the effect people think they have on nature as agents and what we as outside observers make of their practices. The objective is not to assess the veracity of local ideas against ecological ones — both are relative — but to enrich our overall understanding of environmental appreciations within cultural context.

THE WOLA REGION

Wola speakers occupy five valleys in the Southern Highlands of Papua New Guinea ne of Lake Kutubu, between 6° 0'/20' S and 143° 15'/45' E (Map 1). The majority of the population lives at 1600-2000 m asl. The topography is mountainous, rugged and precipitous, with turbulent rivers flowing along the valley floors. The Wola live along the valley sides, leaving the intervening watersheds largely unpopulated. In the valleys, where they have cultivated extensively, there are areas of dense cane grass interspersed with the grassy clearings of fallowed or recently abandoned gardens and the brown earth and dark green foliage of current ones. Lower montane rainforest occurs on the mountains and in the unpopulated parts of river valleys.

The region's climate is of the 'Lower Montane Humid' type (according to the scheme of McAlpine *et al.* 1983:160). It is characterized by high rainfall — annual average 3011 mm — cool temperatures, due to the moderating effect of altitude — mean daily temperature 18°C — and the absence of soil moisture droughts. Varia-



MAP 1. — Map of the island of New Guinea showing the location of Wolaland

tions in topography and altitude give rise to numerous micro-climates locally. The weather is generally equable, many days featuring sunny mornings and rainy afternoons. There are no notable seasons sufficient to influence crop cultivation, although the Wola distinguish two seasons called ***ebenjip*** and ***bulenjip***, which equate with the Southern Hemisphere's summer and winter (Sillitoe 1994). The same climatic conditions largely prevail throughout the year, although unpredictable perturbations can occur, such as overly dry or wet weather, which can adversely affect crop yields.

The substrate environment comprises sedimentary rocks largely, mainly limestone, with igneous rocks of more recent volcanic origin on its margins. In the recent geological past the region was uplifted, then folded and faulted. Frequent earth tremors indicate that these earth movements continue today. The relatively recent occurrence of this folding accounts for the landscape's sharp relief, and was responsible for its current north-west/south-east axis. Contemporary geomorphological processes are changing the region rapidly, maintaining its youthful and raw topography; weathering proceeds apace, erosion is constant, and the occasional large-scale earth movement can dramatically change the local landscape (Löffler 1977).

Soils of the inceptisol and andisol order dominate the region. Soils of other orders (entisols, ultisols, mollisols, and histosols) cover small areas in comparison and are relatively insignificant (USDA 1975; Bleeker 1983). The soils are derived from sedimentary parent materials, variably affected by volcanic ash (from dominated by it, to no evident effects), with some alluvial redeposition. Some are affected by high water content leading to changes in their morphology. Older alluvial soils consist of redeposited volcanic ash; recent ones are of eroded bedrock and redeposited clayey soil. Sandy soils are very localized, occurring largely where occasional sandstone beds outcrop at the surface. Shallow soils too are very limited. Any of these soils may be subject to wet conditions and become a gley, and if the wet conditions are particularly severe and prolonged, peaty soils of high organic matter may develop.

The youth of the soils, combined with several rejuvenating episodes of volcanic ash fall, results in fairly productive soils, with appropriate management. Land-use history depends largely upon horticultural use. Dotted across the landscape are neat gardens. The Wola practice a sedentary variation of shifting cultivation, and subsist on a predominantly vegetable diet in which sweet potato is the staple. Their agricultural practices result in two broad classes of garden: those cleared and planted once with a wide variety of crops (the classic swidden regime), and those planted two or more times, sometimes over and over again for decades, with brief spells in grass fallow. These support a narrower range of crops, largely sweet potato. Gardens range in size from small plots adjacent to homesteads (av. 90 m^2), through taro gardens (av. 495 m^2), to large cultivations of mainly sweet potato (av. 1150 m^2).

The Wola live in squat houses scattered along the sides of their valleys, in areas of extensive cane grassland, the watersheds between being heavily forested. They do not depend on hunting and gathering to supply them with food to any extent, and today make considerably less use of local raw materials to produce things than prior to European contact. They keep pig herds of considerable size.

They hand these creatures, together with other items of wealth such as sea-shells and cosmetic oil, around to one another in an unending series of ceremonial exchanges, which mark all important social events. These transactions are a significant force for the maintenance of order in their fiercely egalitarian, acephalous society. Local social organization also features territorial groups of kin called ***semg^{e}nk*** and ***semonda*** ('small' and 'large families'), which structure access to land. Their supernatural conceptions centre on beliefs in the ability of their ancestors' spirits to cause sickness and death, in various other forest spirit forces, and in others' powers of sorcery and "poison."

METHODOLOGY

The following accounts of vegetational ecology are structured around successions identified and named by the Wola. They distinguish eight major vegetational communities, as follows:

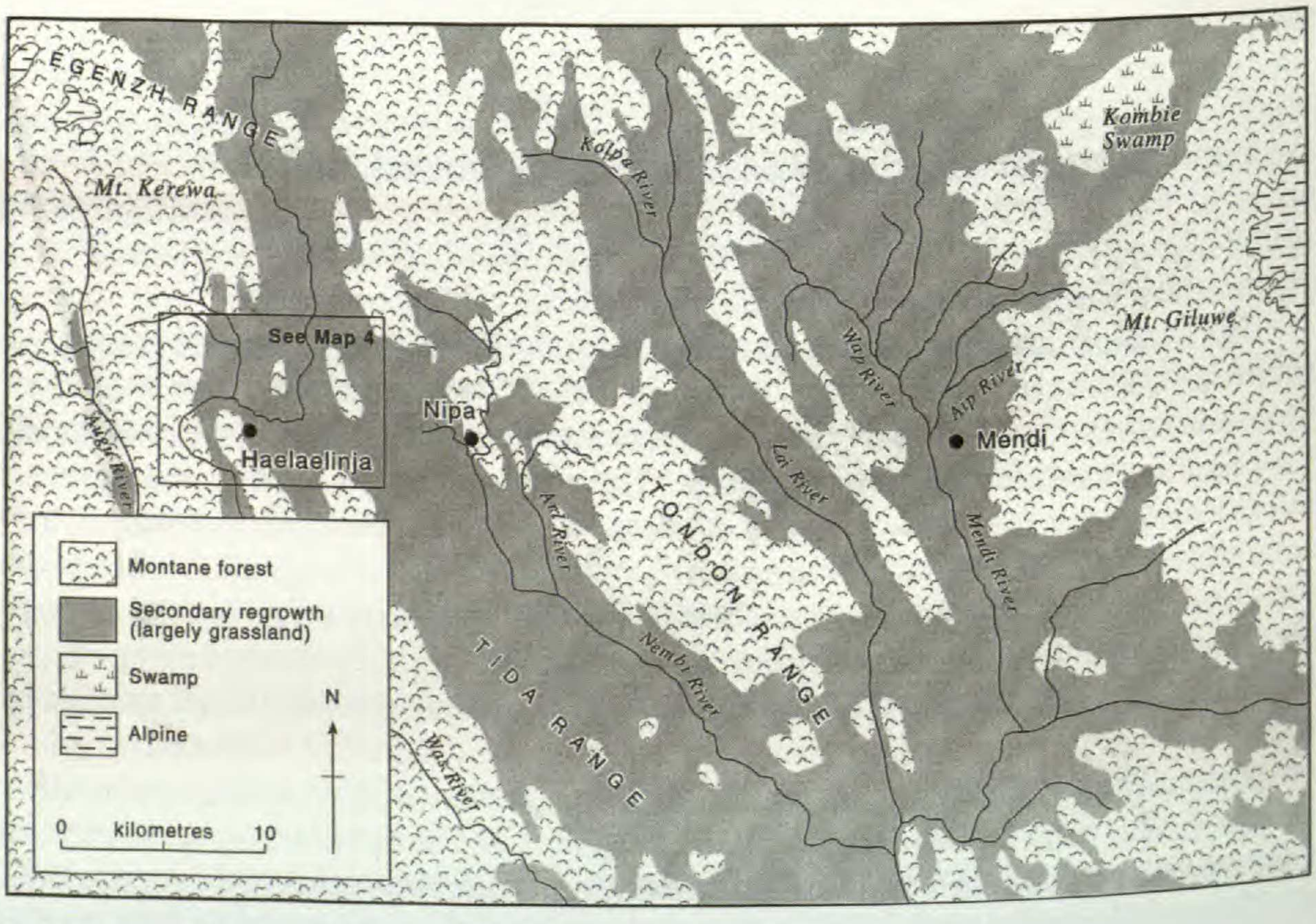
iyshabuw	lower montane rainforest
pa	wetland vegetation
haenbora	rocky vegetation
yom	alpine vegetation
way bway	cultivated vegetation, comprising two locales:
em	gardens
aend bort (or ***aendtay***)	houseyard environs
mokombai	recently abandoned garden successions, including:
taengbiyp	pioneer herbaceous regrowth
bol	later coarse grass regrowth
gaimb	cane grass regrowth
obael	secondary forest regrowth

They distinguish a ninth named community—***pletbok*** 'thicket'—which may occur at locales within some of the above vegetational successions (notably ***iyshabuw, yom, gaimb,*** and ***obael***), that relates more to density of plant growth than species composition or land use.

The method adopted in this investigation of the composition of these plant communities distinguished by the Wola was firstly to gain some idea of their discriminations. On visits to different locales people described successions, relating the plant associations as they saw them. The ethnographer learnt of the different named successions over a period of several years while engaged in research into agricultural practices and environmental issues, the names of vegetation communities coming up in various contexts, often during visits to specific locales. People identified the vegetational communities and related their distinctive composition and discriminatory features, often on site. The knowledge accumulated gradually, the ethnographer becoming increasingly aware of the diagnostic floristic features of communities according to the Wola, following repeated discussions with many people. In this way information was accumulated on the indicator species and floristic structure which the Wola look for in discriminating between named successions.

There followed a series of quadrat surveys to gather quantifiable data on the composition of the various successions (Kershaw 1973; Kent and Coker 1992). These data were recorded in detail in tables, covering each of the different vegetational communities. These tables are arranged according to Wola categories of growth form (woody plants, vines, tree ferns, etc.), and alphabetically by botanical families within each of these categories. They include the Wola name for the plants, together with their species and genera identifications. Space limitations here prevent inclusion of the baseline data for each site. However, that information is available at http://www.dur.ac.uk/~dan0ps/veg.html. Botanical identifications have been substantiated by vouchers, annotated reference specimens being deposited at several herbaria (see Sillitoe 1995a), upon which determinations depended, together with some use of available monographic keys. I relied heavily upon my Wola assistants' knowledge of their region's flora in making discriminations.

The dimensions of the areas surveyed varied according to the size of the vegetation comprising the communities. Where the vegetation included some very large plants (***iyshabuw*** 'montane forest', ***obael*** 'secondary woodland', and ***gaimb*** 'cane grassland'), 10x10 m quadrats were marked out using surveyor's tape, and all of the plants occurring in the demarcated area were counted, excluding fungi and mosses. Where the plants were smaller (***em*** 'gardens', ***mokombai*** 'abandoned gardens', ***haenbora*** 'rockland', and ***pa*** 'swampland' communities), 1 m square portable frames were used, thrown at random in the locations surveyed, and all plants that grew within the area delimited by the squares counted. (The complete original data sets may be requested from the author via e-mail.) When the frames tipped sideways or caught in shrubbery in dense vegetation, we moved plant stems where possible to even them up, or if they were too robust for this, undid one corner of the frame to encompass them. The larger 100 m^2 sites, like those in the



MAP 2. — Map of the vegetation of Wolaland.

forest, were selected at random, using two random numbers per site, to determine compass direction and distance in paced meters from the last site surveyed to the next one. The survey starting points were selected by pointing blindfold at a map of the region.[1] This work was conducted in the Was (Wage) river valley in the region of the locality of Haelaelinja (Map 2).

VEGETATION COMMUNITIES DISTINGUISHED BY THE WOLA PEOPLE

Iyshabuw** 'montane rainforest'.* — The lower montane forest or ***iyshabuw (< ***abuw*** 'wood') is not what one might expect rainforests to be like from popular accounts: dense green walls of thick jungle vegetation. In places it is sometimes of unexpectedly open aspect, with the sky visible through the canopy overhead. It is difficult to evoke the feel of this forest. It is grand; cathedral-like, it inspires humility. It can overawe, particularly those unfamiliar with it, by its size and extent. It is easy to lose one's bearings here. It sometimes worries the Wola too, who may project their fears in the shape of forest-dwelling demon spirits. We recorded at total of 174 plant species in 2500 m^2 of this habitat (Table 1).

The Wola say that the southern beech (*Nothofagus* spp.) predominates in the ***iyshabuw*** forest, with many gigantic mature trees and a considerable scattering of younger ones, plus the occasional dead or dying tree with bare stag-headed crown. The quadrat survey data support their assertions; 12.1% of the large trees in the montane rainforest plots surveyed were *Nothofagus* beech (174 species recorded in 2500 m^2 surveyed). A prominent canopy tree in these highland forests, the beech reaches maximum heights of ±30 m, with branches giving a nearly level or domed canopy (Ash 1982). Beech populations, gregarious and non-allelopathic, characteristically form extensive single genus, even single species stands, which is fairly unusual for tropical forests. A shallow rooting tree, it can be unstable, and in high winds my Wola friends always become very anxious in the forest, fearing tree falls. Its upper altitudinal limit extends somewhat beyond that of cultivation. The montane Wola environment suits *Nothofagus* beech, which favors cloudy regions where precipitation is continuously high. Seedlings require an open tree canopy if they are to complete successfully and grow into mature trees. The proportion of

TABLE 1. — ***Iyshabuw*** rainforest summary composition.

Growth Form	*Families*	*Species*	*Mean % of Species per Quadrat*
Trees	41	109	30%
Tree Ferns	7	15	40%
Ferns	2	2	18%
Screw-pines	1	4	37%
Vines	18	22	36%
Cane Grasses	1	1	4%
Large Herbs	2	6	57%
Grasses and Herbs	10	15	26%
Totals (in 2500 m^2)	82	174	

Nothofagus seedlings and saplings to those of other trees that may grow into the canopy is, at 6.9%, almost one half of the ratio of mature beech trees to other canopy trees, suggesting that proportionately more beeches than other tree species may survive to become forest giants.

The growth rate of young plants increases markedly with the creation of gaps in the canopy through senescence or tree fall, as the Wola are aware. They sometimes create spaces by felling trees to encourage the growth of selected saplings, such as those that yield edible nuts or fruits. These occur with natural dieback too, sometimes of several trees and even entire patches of forest, associated with a combination of unfavorable weather and pathogenic attack (Kalkman and Vink 1970). The beech is not a colonizing genus, regeneration scarcely extending beyond the canopy of *Nothofagus* stands (Walker 1966), which is interpreted as evidence that today's stands are relics of once more widespread beech forests upon which other genera have encroached (Ash 1982).[2] In the Wola region it is common for discrete patches of beech forest to occur surrounded by multi-genera forest (Robbins and Pullen 1965; Kalkman and Vink 1970; Walker 1966). According to Ash (1982), beeches overall comprise between 10% and 20% of the canopy trees in lower montane forest, which complies with the quadrat survey findings reported here.

While beech is dominant, other trees may occur in considerable numbers, rivalling the beech in places, giving a mixed aspect to large tracts of forest (see Table 12).[3] They include oaks (*Lithocarpus* and *Castanopsis*), like the southern beech, members of the Fagaceae, and have retained similar ecological habitat compatibilities. Wola point out that *Lithocarpus* oaks are particularly common in heavily disturbed forested pockets on lower valley slopes. Other trees here include figs (*Ficus*), colas (*Sterculia*), white magnolias (*Galbulimima*), gamboges (*Garcinia*), and elaeocarps (*Elaeocarpus*), among others. The trees form a ca. 80% canopy cover at about 30 m, with some emergents above it, and sometimes with a secondary or diffuse layer at ±20 m, all competing for a share of the light. Our Wola consultants say that it is difficult to identify any clear stratification in the forest because of the overlapping crowns in the various layers. The trees are also shallow rooting on the whole like *Nothofagus*, with most of their roots fairly evenly distributed in the top 20-30 cm of the soil (Edwards and Grubb 1977, 1982). The ground cover is frequently heavy, often restricting visibility, and varies from dense stands of saplings and shrubs (including species of Melastomaceae, *Phyllanthus, Pipturus, Cyrtandra, Piper, Symplocos,* and *Daphniphyllum*), to impenetrable tangles of slender-stemmed climbing bamboo (*Racemobambos congesta*), which men sometimes cut down and wrap around their heads like foliage wigs. There are also masses of fleshy leafed herbs, notably gingerworts (Zingiberaceae, Urticaceae) and ferns, both tree ferns (Cyatheaceae) and in places numerous low clump ferns (*Cyclosorus*), which the Wola also favor, picking fronds for personal decoration, a sign that they have been in the forest (Table 1).

The forest has a wet aspect, dripping much of the time, frequently enveloped in low cloud and subject almost daily to considerable rainfall. The wetness is one of the most tiresome aspects of forest travel because it renders everything slippery underfoot. Mosses (*Frullania, Meteorium, Bazzania, Dicranoloma,* and *Lepidozia*) thrive in this environment, and thick mats festoon trees and shrubs; men also use these on occasion for wig-like decoration. A springy bed of mosses, which together with a thick layer of rotting vegetation and fallen leaves, covers the ground, forming a raw or partially decomposed litter through which surface roots run. The forest floor is criss-crossed with surface and stilt roots and fallen timbers. With the uneven ground, pitted by hollows and crevices, and the standing vegetation, traveling is awkward off the established paths, and progress slow.

The trees also support a variety of climbing plants, from woody lianas (*Alyxia*, *Cayratia*, and *Dimorphanthera*) to palms (*Rattan*) and pandan vines (*Freycinetia*), all twining strongly around their trunks, growing into canopy gaps to the light overhead. Trees act as hosts for many epiphytic plants too, all of which thrive in the humid atmosphere of the forest. They range from bryophytes on trunks, to vascular epiphytes and ferns on branches, to sooty moulds on leaves. On the crown branches of some trees there is a peat-like accumulation comprising the remains of epiphytes and litter which forms a substrate for larger epiphytic plants, and occasionally for some tree species which are more often found growing on the ground. These include *Schefflera*, *Pittosporum*, *Timonius*, and *Gardenia*. One way the Wola explain that these trees germinate in the crowns of larger trees is by birds depositing seeds there in their droppings. They name the red-capped flowerpecker (*Dicaeum geelvinkianum*) it ***mondiytiylkaelenj*** (literally, '***mondiyt***-shrub' + 'seed') for the fact that it propagates this shrub by distributing its sticky seed via its droppings. Older and larger trees predictably support more climbers and epiphytes. Epiphytic orchids (*Dendrobium*), together with some other flowering herbs, add a splash of color to the dank grey-green background. Sometimes people pick them and push them into their hair as ornamentation.

A feature of the forest familiar to the Wola is the similarity and continuity of its structural form and floristic composition through a range of stands. Obvious environmental variations occur, which are sometimes remarked upon by the Wola, as for instance, in wet or waterlogged pockets, on bare steep slopes, and along watercourses. Landslides and slips, if extensive, can also change the floristic community, although the most pervasive interference and consequent modification of successions results from the actions of human beings. While the forest is predominantly primary, human activity has disturbed considerable tracts (Flenley 1969). In some places the interference is minimal, a hunter perhaps having felled a tree or cleared some undergrowth. In other places the disturbance is extensive, a man having maybe established a clearing to allow the sun access to nut-bearing screw-pines (*Pandanus julianettii*). These areas may become quite large, developing into pandan groves. Wild pandans elsewhere in the forest grow singly, here and there. Nearer to settlements people have considerably disturbed the forest and altered its floristic composition, with fewer beech and more faster growing, softer-wooded species evident.

Forest wildlife is diverse, though less conspicuously vocal than at lower elevations. Some forest birds are highly valued for their plumes, which are wealth in ceremonial exchanges. Common mammals include cuscuses, opossums, and tree kangaroos. A wide variety of rodents, including giant rats, also occurs, as does the rare spiny egg-laying echidna of remote forested regions. Birds are numerous, including the large flightless cassowary, various small flycatchers, colorful parrots and lories, soft-hued pigeons, numerous honeyeaters, and New Guinea's renowned birds of paradise. Reptile and insect populations are also numerous and varied. But hunting is not a regular pursuit.

The forest supplies other edible products, notably fungi, which people collect irregularly. It is also the source of raw materials used in the production of artifacts. But Wola attitudes to the resource-rich forest are ambivalent. They enjoy it, but are sometimes wary of it; they value it but are piecemeal destroying it. They do not readily speak expansively about the forest, beyond saying that it is a large and sometimes dangerous place, a place to hunt and a source of raw materials. But their fear of forest demons expresses something of their deeper attitudes and ambivalence. It is possible to lose your way in unfamiliar regions. Accidents are more likely in the forest, where shallow rooted trees blow over in high winds. One may fall on the frequently broken and slippery terrain and injure oneself. Fatalities occur. The Wola explain the misfortunes that may befall people there as caused by demon spirit creatures called ***saem*** and ***iybtit***, which inhabit forests at higher and lower altitudes respectively.

These dangerous spirits may strike those who are reckless or thoughtless. Thus, the deep forest is not somewhere to go lightly. This could be interpreted as promoting a regard for the forest, perhaps even a degree of environmental awareness, intimating disquiet over forest destruction. Moreover, one should beware indiscriminately damaging the forest, as one may offend a demon. However, this demon complex does not reflect a conscious recognition of the need for forest conservation. The forest is too vast for the Wola to conceive of its destruction, as it may take days to walk through it. It is plausible to interpret their demon beliefs as paradoxically endorsing such action, in that by destroying the forest they are exerting some control over frontier areas, driving demons from their homeland by depriving them of a place to live. Where there is no rain forest, there are no demons. However, the idea of destroying all their forest would be unthinkable to the Wola. The ambivalence they feel is captured in their demon fears.

Pa *'swamp vegetation'*. — Wetland communities, varying in size, occur throughout forests and grasslands, They occur on poorly-drained sites called ***suw pa*** ('bog place'). Depending on the depth of the water table, these areas vary from spongy damp swards to waterlogged swamps. Water-loving grasses (e.g., *Leersia, Ischaemum, Isachne, Panicum*), which dominate swards, and herbs such as sedges (*Cyperus, Kyllinga*), horsetails (*Equisetum*), and water-parsley (*Oenanthe*), grow in low tussocks. A scattering of wild sugar (*Saccharum robustum*), clumps of cane grass (*Miscanthus, Coix*), and the occasional tree or dwarf shrub, such as water-gums (*Syzygium*), icacinads (*Rhyticaryum*), and she-oaks (*Casuarina*) occur, particularly on the swamp margins (see Table 2, 11;. 34 species were recorded in 50 m^2 of this habitat).

The presence of hydrophytes is indicative of locations with gleyed soils, which the Wola favor for taro cultivation, for which they are well suited. These ***ma em*** 'taro gardens' may support a range of crops in addition to taro, though taro tends to predominate, particularly in mature gardens (Table 3, 11; 47 species were recorded in 32 m^2 of this habitat). Other crops are most often planted on drier hillocks and around tree stumps, including various cucurbits and leafy greens, such as crucifers and acanths (Sillitoe 1983). The weeds that colonize these sites are similar to those found in other gardens (described below).

Swamp forest occurs in some waterlogged locales, generally of limited extent

TABLE 2. — ***Pa*** swampland summary composition.

Growth Form	*Families*	*Species*	*Mean % of Species per Quadrat*
Trees	1	1	2%
Tree Ferns	2	2	2%
Vines	1	1	2%
Cane Grasses	3	3	3%
Grasses and Herbs	11	25	18%
Crops	2	2	43%
Totals (in 50 m^2)	20	34	

(Johns 1980). Conifers are common here (indicator species include *Dacrydium, Podocarpus*), together with a range of other trees (*Glochidion, Maesa, Homolanthus*), giving a variable canopy beneath which occurs a dense layer of shrubby vegetation. The forest floor is fairly open with pools of water separated by irregular hummocks. Botanists have suggested that these conifer-dominated swamp forests may have arisen due to extreme frosts killing off broadleaved trees (Robbins and Pullen 1965), or they may represent an early stage in mixed montane swamp forest development (Johns 1980). The wildlife populations supported by any wetland area depends on and reflects the surrounding vegetational community, plentiful if forest, more meagre if grassland.

Haenbora *'rocky vegetation'*. — Rocky locations that support some plant life are called ***haenbora.*** These occupy limited areas of thin skeletal soil found throughout the Wola region. They vary in extent, but are generally small. The vegetation consists of hardy plants capable of colonizing thin regolith (see Table 4, 11; 18 species were recorded in 10 m^2 of this habitat), notably mosses initially (*Frullania, Meteorium*), followed when a suitable soil-like deposit has accumulated, by some ferns (e.g., *Pteridium, Cyclosorus*), hardy orchids (*Spathoglottis*), stunted grasses (*Imperata, Miscanthus*), and the occasional dwarfed sapling (*Dodonaea, Ficus, Acalypha*). These locales are of no horticultural use, although they are sometimes disturbed by, for example, when people burn off nearby cultivated areas. These rocky sites may be

TABLE 3. — ***Ma em*** taro garden summary composition.

Growth Form	*Families*	*Species*	*Mean % of Species per Quadrat*
Trees	9	12	15%
Tree Ferns	1	1	19%
Cane Grasses	1	1	19%
Large Herbs	1	1	50%
Grasses and Herbs	11	20	24%
Crops	9	12	19%
Totals (in 32 m^2)	32	47	

TABLE 4. — ***Haenbora*** rockland summary composition.

Growth Form	*Families*	*Species*	*Mean % of Species per Quadrat*
Trees	2	2	30%
Tree Ferns	2	2	45%
Ferns	1	1	10%
Vines	2	2	15%
Cane Grasses	1	1	40%
Large Herbs	1	1	10%
Grasses and Herbs	6	9	54%
Totals (in 10 m^2)	15	18	

used for burials, which people fear as places frequented by ancestral ghosts, making them doubly unsuitable for cultivation or other human use.

Yom *'alpine vegetation'*. — Alpine heath and grassland vegetation, called ***yom***, occurs on the high volcanic summits that flank Wolaland to the east and west. It is of little concern to the Wola, with few resources of use to them. One exception is the hardy pandan called ***dalep*** or ***tuwmok*** (*Pandanus brosimos*). Some men collect their nuts in season. Alpine areas are considered dangerous places because of forest demons, and best avoided. The flora is a tussock grassland (of e.g., *Danthonia, Poa, Deschampsia, Festuca*), with small heath-like shrubs (*Rhododendron, Coprosma, Styphelia*), low herbs (*Ranunculus, Gentiana, Lycopodium*), and gaunt, stunted tree ferns (*Cyathea*). The festucoid composition of mountain grasslands contrasts with the panicoid one of lower regions. The flora, with its gentians, buttercups, and fuschias is reminiscent of New Zealand (Robbins 1961). Mires are common, with hummock plants and shrubs (*Gleichenia, Trochocarpa, Astelia*) prominent in stagnant acid bogs and sedges and grasses (*Carex, Brachyposium*) in fens with moving water.

At high altitudes the forest adjoining these alpine grasslands may be of a quite different aspect to that lower down, although still called ***iyshabuw***. Cloud envelops it daily, influencing its floristic composition. It is a single-tree-layered forest (*Rhododendron, Rapanea*), of stunted and crooked aspect, with a low (10 m) canopy, except for some emergent trees (*Papuacedrus, Schefflera, Dacrycarpus, Saurauia, Podocarpus*). Mosses and liverworts are also common, festooning lower branches, exposed roots, and crooked trunks; they may even cover the tangled roots and decaying forest debris on the forest floor in a thick, wet, spongy carpet. Sprawling shrubs are also common (*Vaccinium, Coprosma, Dimorphanthera*). A dynamic transition zone exists between forest and high altitude grassland, creeping shrubs colonizing grassy areas by vegetative propagation, while grasses encroach on shrubbery after its occasional destruction in fires (Gillison 1969, 1970). These regions are of no horticultural significance, being beyond the altitudinal range of crop plants.

Pletbok *'thickets'*. — Thickets, particularly of fern, are common in this high-montane cloud forest. The Wola refer to these areas as ***pletbok***, a term for any dense and impenetrable stand of vegetation that requires the cutting of a path through it. Although ***pletbok*** thickets are common at higher altitudes, they are not restricted to these locales, also occurring in rain forest and mature secondary successions at lower elevations. They are usually of restricted occurrence. They commonly comprise a tangle of ferns (*Dicranopteris*), climbing bamboo vine (*Racemobambos*), sword grass clumps (*Miscanthus*), together with low bushy saplings. People tend to avoid thickets, as they are difficult to penetrate, though they may harbor game or occur on a site being cleared for cultivation.

Way bway *'cultivated communities, gardens and homesteads'.* — The Wola call their gardens collectively ***em***, distinguishing several kinds. Here they cultivate a wide range of crops (Sillitoe 1983). Newly established gardens, particularly those adjacent to homesteads, feature a wide range of intercropped plants (see Table 5, 11; in two plots, each 42 m^2, we recorded 54 and 55 species [77 total], of which 20 and 9 were cultivated, respectively).

Longer established plots have less crop variety, sweet potato vines (*Ipomoea*) predominating over large areas, interspersed with some pumpkin (*Cucurbita*), sugar cane (*Saccharum*), green leafy vegetables and shoots (*Rungia, Setaria*), and other crops (see Table 6, 11; in two plots, each 42 m^2, we recorded 52 and 28 species [54 total], of which 12 and 6 were cultivated, respectively).The occurrence of crops in sweet potato gardens does not differ greatly with the time they have been under cultivation, as shown by a comparison of data from gardens cleared once, two-four times, and five or more times (Table 7).

All of these gardens support large numbers of sweet potato plants, usually cultivated in mounds. There is an evident increase in sweet potato plants per unit area as gardens age, from 16 to 18 to 21 plants per m^2, but the range of crops cultivated does not change noticeably. This suggests that no dramatic changes occur in garden fertility over time, corroborating people's assertions that sweet potato tuber yields vary little between gardens of differing ages. The Wola cultivate a range of other crops in small fertile strips along downslope fence lines, in surface dips, and so on.

A range of cultivated plants also occurs in houseyards, called ***aend bort*** (literally, 'at house'), and to a lesser extent around adjacent ***howma*** ceremonial grounds. People cultivate long-term crops around the edges of these clearings, such as bamboo (*Nastus*), palm lilies (*Cordyline*), bananas (*Musa*), screw-pines (*Pandanus*), and

TABLE 5. — ***Em*** garden (planted once) summary composition.

Growth Form	*Families*	*Species*	*Mean % of Species per Quadrat*
Trees	8	12	6%
Tree Ferns	2	3	15%
Cane Grasses	1	2	4%
Large Herbs	1	1	7%
Grasses and Herbs	19	39	27%
Crops	14	20	19%
Totals (in 84 m^2)	45	77	

TABLE 6. — ***Em*** *garden* (planted twice or more) summary composition.

Growth Form	*Families*	*Species*	*Mean % of Species per Quadrat*
Trees	6	7	5%
Tree Ferns	1	1	2%
Cane Grasses	2	2	4%
Grasses and Herbs	18	33	29%
Crops	8	11	19%
Totals	35	54	

TABLE 7. — Comparison of productivity of gardens cleared once, two-four times, and five or more times by mean number of plants per m^2.

	Mixed vegetable gardens	Sweet potato gardens: planted once	planted 2-4 times	planted >5 times
Sweet potato	0.36	15.80	17.90	20.70
Leafy vegetables and shoots	10.02	0.91	1.38	0.12
Pulses	0.57	0.07	0.10	0.10
Crucifers	1.86	0.27	0.04	0.14
Cucurbits	0.57		0.02	
Aroids	0.14		0.02	

ornamental plants for body decoration (*Acalypta, Laportea, Graptophyllum*). They may also cultivate on occasion plants that supply useful materials, such as hoop-pines (*Araucaria*), she-oaks (*Casuarina*), spurges (*Euphorbia*), bead ashes (*Elaeocarpus*), and marants (*Cominisia*).

Some wild plants that invade garden sites are edible too, and on occasion people cultivate them (e.g., *Commelina, Oenanthe, Solanum*). Others are not utilized directly by the Wola, although they may protect soils against erosion (Sillitoe 1993). Different associations of weedy plants are related more to the natural vegetation adjacent to sites, and hence to seed supply, than to any other factor.

Mokombai *'recent regrowth'*. — Recently abandoned, gardens, called ***em mokombai*** ('immature-regrowth garden'), pass rapidly through a series of overlapping plant successions before either tree or sword grass regrowth become established. These communities are botanically varied, changing quickly. Recently abandoned garden sites are irritating to traverse, colonized by herbaceous plants which rely on spiky and sticky burrs to disperse their seeds, called generically ***kobkob*** by the Wola (e.g., *Bidens pilosus, Adenostemma lavenia, Cynoglossum javanicum*).

Abandoned gardens are invaded by pioneer grasses (e.g., *Arthaxon, Paspalum, Ischaemum, Setaria, Isachne*) and herbs (*Crassocephalum, Polygonum, Viola,* and *Rubus,* among others). These flourish at the expense of the few remaining crop plants, finally displacing them (see Table 8, 11; 47 species were recorded in 50 m^2 of this habitat). The Wola may refer to this early ***mokombai*** phase as ***taengbiyp*** after one of the grasses that characterizes it.

TABLE 8. — ***Mokombai taengbiyp*** summary composition.

Growth Form	*Families*	*Species*	*Mean % of Species per Quadrat*
Trees	4	4	2%
Tree Ferns	3	4	6%
Ferns	1	1	4%
Cane Grasses	1	1	8%
Grasses and Herbs	15	31	24%
Crops	5	6	22%
Totals (in 50 m^2)	29	47	

Certain crops, like sweet potato, highland pitpit (*Setaria*), bananas, sugar cane, and the coleus dye plant (*Plectranthus*), compete successfully with the invading weeds and maintain their position on the site for some time. Eventually, robust and vigorous grasses (notably *Ischaemum*, but also *Paspalum*, *Arthraxon*, and *Isachne*) take over, possibly with swamp grass (*Leersia hexandra*) in wet depressions, replacing both any remaining crop plants and many of the early weed colonizers (see Table 9, 11; 50 species were recorded in 50 m^2 of this habitat). Wola commonly refer to this later ***mokombai*** phase as **bol**, after the coarse *Ischaemum* grass that is predominant.

Some garden fallows never advance beyond one or another of these stages of regrowth, as people may pull up the herbaceous regrowth or coarse grasses and re-cultivate the sites. If natural regeneration proceeds, saplings, cane grass, or both invade (see Walker 1966 for a schematic representation of various possible sequences). Perennial short grassland like that in the Eastern Highlands is uncommon, probably because of the higher year round rainfall (Henty 1982), although small patches of ephemeral kunai grass (*Imperata*) occur, which the Wola call **senz** after that species, and which they exploit for house thatch. In the drier eastern regions of the New Guinea highlands, burning is more frequent and destructive, helping maintain a more extensive continuous cover of short grasses; it is not necessarily more mature than a cane grass cover nor an indication of earlier settlement and longer disturbance (Robbins 1960).

TABLE 9. — ***Mokombai bol*** summary composition.

Growth Form	*Families*	*Species*	*Mean % of Species per Quadrat*
Trees	3	3	4%
Tree Ferns	1	2	8%
Ferns	1	1	2%
Vines	2	2	3%
Cane Grasses	1	1	6%
Grasses and Herbs	20	38	22%
Crops	3	3	9%
Totals (in 50 m^2)	31	50	

Gaimb *'cane grassland'*. — In the long-term one of two major floristic successions will establish themselves on abandoned cultivation sites: cane grass or secondary forest. The Wola call communities dominated by sword or cane grass (*Miscanthus floridulus*) ***gaimb*** after that predominant species. Cane grassland, like secondary forest, occurs predominantly as garden regrowth, although it sometimes colonizes sites disturbed and deforested for other reasons. *Miscanthus* is an erect cane-like grass with robust culms. It grows in dense clumps. Its lanceolate leaves, two-three cm wide, have finely serrated margins and taper to sharp points. Its inflorescence is a large, open panicle (Henty 1969). It produces large amounts of fluffy wind-borne seed, well adapted to colonize disturbed locales at a distance. It is prolific, even when cut right back. Eradicating it when clearing a new garden, for example, demands levering out the rootstock clump.

Dense stands of *Miscanthus floridulus*, 2-3 m high, cover large areas in valley basins. The quadrat survey data indicate up to 30 large clumps per 100 m^2 where it predominates. It may comprise 90% or more of the ground cover.[4] The cane forms a dense ***pletbok*** 'thicket' which is frequently impenetrable without a bush knife to cut a path. Thick brakes of fern (*Dicranopteris*) also occur in some locations among the cane, and clumps of low fern (Thelypteridaceae) are common where the cane is less dense. The cane is more open near homesteads where the rooting of pigs expose earth around the cane clumps. Even here a fair layer of leaf and cane stem litter builds up, supporting local assertions that under cane grass fallow a good layer of high organic dark topsoil suitable for recultivation soon accumulates. *Miscanthus* appears less readily to colonize sites close to the forest edge or other shaded places, which seem to reduce its competitive ability (Walker 1966).

Other grasses that occasionally occur amongst the *Miscanthus* include Job's Tears (*Coix lachryma-jobi*), wild sugar (*Saccharum robustum*), particularly along stream banks, and an "elephant grass" (*Pennisetum macrostachyum*) on wooded margins. Where the cane is more open and the soil not turned over too frequently by rooting pigs, low grasses (*Isachne, Paspalum, Ischaemum, Sacciolepsis, Setaria*) and various herbaceous plants (various Compositae, *Desmodium, Selaginella, Oenanthe, Plectrantus, Rubus, Viola*) may form a ground cover (see Table 10, 11; 148 species were recorded in 2000 m+ of this habitat).

Cane grassland is second only in extent to montane forest and has gradually replaced forest as the human population has expanded. Though cane grassland appears monotonous, floristic analysis suggests that it is a surprisingly species-rich succession (Figure 1). When established, cane grassland supports a few scattered trees, notably lower-statured, soft-wooded species such as nettles (*Pipturus*), ochnas (*Schuurmansia*), silkwoods (*Cryptocarya*), dillenias (*Saurauia*), and woolly cedars (*Trema*), with she-oaks (*Casuarina*), figs (*Ficus*), switchsorrels (*Dodonea*), parchment barks (*Pittosporum*), umbrella trees (*Schefflera*), and others. Stands of cultivated screw-pines (*Pandanus*) are also common, remaining from previous gardens. They sometimes grow in rows with palm lilies (*Cordyline*), marking old fence lines. The graceful tree fern (Cyathaceae) is common too, producing a distinctive vegetational succession. Wola do not distinguish this succession as a separate community, beyond speaking of them as ***henk***, the Wola life-form term for tree ferns.

A *Miscanthus* succession generally replaces shorter grasses if a site is left undisturbed, the tall cane out-competing even vigorous and persistent *kunai* grass

TABLE 10. — ***Gaimb*** cane grassland summary composition.

Growth Form	*Families*	*Species*	*Mean % of Species per Quadrat*
Trees	30	66	20%
Tree Ferns	7	12	33%
Ferns	3	3	33%
Screw-pines	1	1	35%
Vines	16	18	17%
Cane Grasses	1	2	68%
Large Herbs	2	5	23%
Grasses and Herbs	21	38	33%
Crops	3	3	45%
Totals (in 2000 m^2)	84	148	

TABLE 11. — ***Obael*** secondary forest summary composition.

Growth Form	*Families*	*Species*	*Mean % of Species per Quadrat*
Trees	29	64	19%
Tree Ferns	7	13	34%
Ferns	4	4	40%
Screw-pines	1	1	5%
Vines	14	15	12%
Cane Grasses	1	3	40%
Large Herbs	2	6	17%
Grasses and Herbs	19	36	34%
Crops	4	4	33%
Totals (in 2000 m^2)	81	146	

(*Imperata conferta*). The conditions that promote *Miscanthus* in competition over *Imperata* are an absence of extensive burning, which the wet Southern Highland's climate generally assures, and the presence of foraging pigs (Walker 1966). Not all grassland successional changes are due to human interference. Earth movements can disturb plant communities, sometimes permanently if drainage is altered. It has been suggested that some cane grassland was established during the Pleistocene glaciation, glacial evidence, such as moraines, existing on high volcanic peaks (Walker and Flenley 1979). However, Wola attribute such changes primarily to their activities, as the major disturbers of vegetation.

Human activity has undoubtedly extended the area under grassland. Grasslands occur where neither climate nor soil would preclude the growth of forest. Forest-grassland boundaries frequently occur independently of changes in soil types, having no apparent relationship with them. This is taken as evidence that grassland is largely anthropogenic (Robbins 1960; Henty 1982). Repeated cultivation, shortened fallow cycles, grass fires, and other disturbances encourage cane grass following forest clearance. Environmental factors that assist seedling death, such as soil-plant nutrient imbalances and sub-optimal drainage conditions, also contribute. Wola acknowledge that they themselves are agents of the forest's destruction. Once in digging a ditch to enclose a garden in cane grassland, gnarled bits of beech root and tree stump were uncovered, which were readily explained as evidence that the area was once forest.

Obael *'secondary forest'*. — The alternative long-term floristic succession to cane grass following the clearance of any area for cultivation is secondary forest. When plots cleared for gardens in the rainforest are abandoned they rapidly regenerate into patches of secondary forest , which the Wola call ***em obael*** ('mature-regrowth garden'). Tree regrowth occurs too in pockets throughout the cane grassland zone. It has a markedly different floristic composition to montane forest. It is altogether of a softer aspect and less formidable.

The ***obael*** secondary forest has a considerably lower canopy than the ***iyshabuw*** montane forest at 10-20 m and comprises fast growing soft-wooded trees primarily, such as various spurges (Euphorbiaceae), pipers (Piperaceae), nettles (*Pipturus*), figs (*Ficus* spp.), umbrella trees (*Schefflera*), dillenias (*Saurauia*), silkwoods (*Cryptocarya*), woolly cedars (*Trema*), and switchsorrels (*Dodonaea*) (see Figure 1; 146 species were recorded in 2000 m^2 of this habitat). Tree ferns (Cyatheaceae) are also common, often occurring as an understory tree (Table 11). Clumps of cane grasses (*Miscanthus, Coix*) are common too. When these exceed a certain number, the regrowth becomes more akin to cane grassland; there is no sharp distinction between these two vegetational communities, nor any others that pass from one to another. They gradually merge, as the Wola acknowledge, with no abrupt change.

The ground cover is on the whole considerably less dense under secondary woodland than primary forest, consisting of various coarse and creeping grasses (*Paspalum, Setaria, Ischaemum*), and a range of herbs and shrubs (Compositae, *Desmodium, Impatiens, Oenanthe, Plectranthus, Polygonum, Selaginella*), sometimes growing to waist height. Ferns are also common, notably in sprays across the forest floor (Thelypteridaceae) and sometimes in tangles (*Pteridium, Dicranopteris*); tall leafy herbs, notably gingers (Zingiberaceae), are frequently seen. The wildlife inhabiting secondary forest depends on its location. When surrounded by montane forest, where wildlife is abundant, it is likewise plentiful. But when situated island-like in a sea of cane grassland, where wildlife is limited, it is sparse. However, the fruits of some trees growing in these wooded islands are popular with birds and attract them here in considerable numbers when ripe.

Areas of secondary forest rarely develop into mature wooded stands. People with rights to the land usually clear them again for gardens before they reach this stage, or otherwise hinder their development by collecting firewood and raw materials. Near homesteads, they are sometimes disturbed by pigs rooting for food, which leaves patches of churned sod and vegetation across them. Nonetheless, if left undisturbed, the Wola maintain that ***iyshabuw*** forest would eventually establish itself in these areas. Some men told me that if they abandoned their valleys, montane rainforest would eventually replace both ***obael*** secondary forest and ***gaimb*** cane grassland, to cover them just as it had before their ancestors cleared it. They spoke of the primary forest 'hitting and eating' (***luw nokor***, literally, 'hit will eat') these long-term secondary successions and 'making them rotten' (***kor ma sokor***, literally, 'rotten cause become'). They pointed out locations where secondary woodland and cane grass abut the forest and explained how with human-beings absent the montane forest would slowly advance down the valley sides; they cited the Augu valley as a place where this has occurred in living memory, for with the abandonment of gardens there (following the establishment of administrative centers elsewhere, prompting people to move to be closer to them), the forest is engulfing the ***obael*** woodland and ***gaimb*** grassland down to the edge of the Augu river.

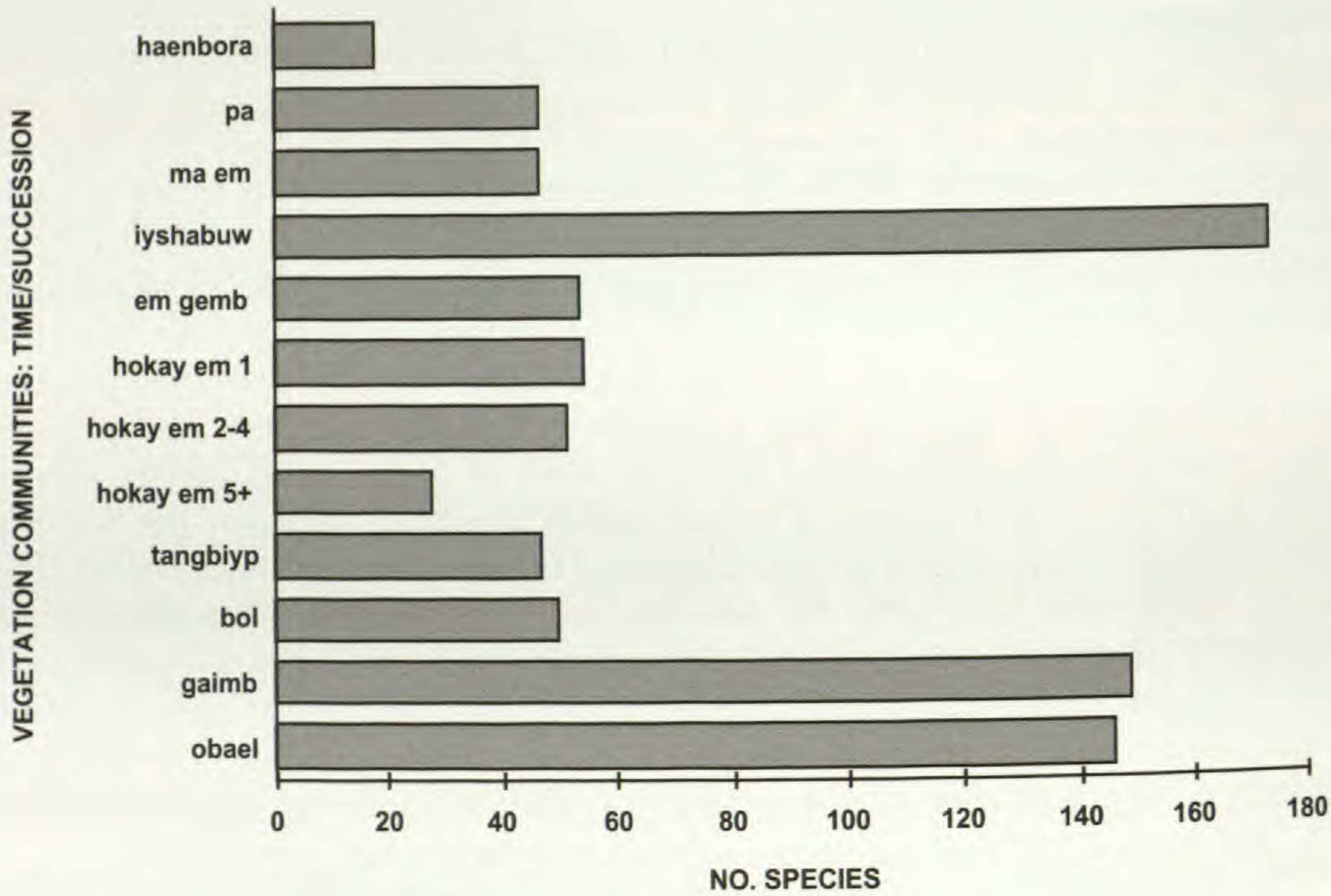
VEGETATIONAL SUCCESSIONS AND CHANGE

Changes in vegetational composition with human interference, in which the foregoing seral communities feature prominently, do not necessarily spell irreversible degradation, with permanent reduction in species diversity and biomass, at least not in the long run. While there is piecemeal destruction of forest to establish new gardens, this may be interpreted as the start of a long term chain involving garden and houseyard sites, which may pass through a series of successions upon abandonment to become cane grass and/or secondary forest regrowth, even mature forest if left long enough, although more likely they are disturbed again at some time relatively early in their progression towards maturity. The different plant communities recognized by the Wola relate to a presumed floristic successional pattern, a development relationship existing between the various anthropogenic communities and the unaltered forest and other communities (Figure 1). These data also belie the assumption that secondary successions are floristically degenerate, mature ones approaching primary forest in species richness; the Shannon and equitability indices support this conclusion (Table 12). While humans have contributed to deforestation and the spread of ecological disclimax vegetation, their activities do not necessarily result in a one-way change nor long term degradation, at least according to Wola experience and perceptions.

The assumption that a floristic succession characterizes changes in vegetation communities informs Wola thinking, who maintain that over time disturbed land passes through a series of named successions; this assumption also implicitly informs the structure of this paper. A statistical assessment of similarity between the vegetational communities distinguished further supports the postulated successional.[5] The cluster dendrogram sequence (Figure 2) groups together the various sites under cultivation, together with those under early abandoned vegetation, as similar in composition, in contrast to primary forest and advanced secondary successions under trees and cane grass, with bogland and rocky outcrop communities separated as quite different (a multidimensional scaling analysis mapped the distances similarly).

It is more difficult to appreciate Wola perceptions of the changes which their activities cause to vegetation communities, although the species richness and similarity evidence hints at their views and lends them some credence. Apparently, they do not think of themselves as irrevocably destroying virgin plant associations. The different plant communities which they distinguish and name are broad, relatively ill-defined categories. While they cite certain plants as indicator species of different communities, even naming some of them after these predominant plants (like ***gaimb*** for cane grassland and ***bol*** for coarse grass regrowth), they do not justify their identification of communities in terms of certain proportions of specified plants occurring there. This approach to community definition characterizes ecological science. It is used in this paper to achieve a more precise characterization of plant communities as identified by the Wola. While there is some broad correspondence, local and scientific ideas of botanical and ecological zones over-

FIGURE 1. — Species richness and characteristic taxa of climax and seral communities, according to relative time-succession order.



Checklist of taxa characteristic of each community in the development sequence	
Haenbora	*Eulalia, Imperata, Spathoglottis, Pteridium*
Pa	***Leersia**, Panicum, Oenanthe, Isachne, Ischaemum, Cyperus, Kyllinga*
Ma em	***Colocasia**, Crassocephalum, Nasturtium, Amaranthus, Viola*
Iyshabuw	***Nothofagus**, Ficus, Garcinia, Saurauia, Lithocarpus, Castanopsis, Elaeocarpus, Dicksonia, Alpinia, Cyclosorus, Racemobambos, Freycinetia, Polystichum, Phyllanthus, Cyrtandra, Cyphlophus.*
Em gemb	*Various crops, Setaria, Oenanthe, Bidens, Paspalum, Polygonum*
Hokay em 1	***Ipomoea**, some crops, Bidens, Centella, Cynoglossum, Polygonum*
Hokay em 2-4	***Ipomoea**, Adenostemma, Crassocephalum, Isachne, Polygala, Viola*
Hokay em 5+	***Ipomoea**, Arthraxon, Paspalum, Polygonum, Bidens*
Taengbiyp	***Arthraxon**, Adenostemma, Rubus, Cynoglossum, Paspalum, Viola*
Bol	***Ischaemum**, Isachne, Pouzolzia, Paspalum, Polygala, Polygonum*
Gaimb	***Miscanthus**, Blumea, Centella, Cyathea, Cyclosorus, Desmodium, Plectranthus, Schuurmansia, Selaginella, Oenanthe, Bidens*
Obael	*Trema, Piper, Cryptocarya, Dodonea, Saurauia, Pipturus, Pittosporum, Desmodium, Garnotia, Impatiens, Miscanthus, Paspalum, Plectranthus, Polygonum, Selaginella, Sphaerostephanos*

TABLE 12. — Shannon (H') and equitability (E) indices for vegetation communities (for definitions see Note 3).

	H'	E
Iyshabuw *'primary forest'*	3.80	0.74
Pa *'swampland'*	1.70	0.48
Ma em *'taro garden'*	2.83	0.74
Haenbora *'rockland'*	0.56	0.19
Em gemb *'houseyard garden'*	3.15	0.79
Em *garden (planted 1x)*	2.70	0.67
Em *garden (planted 2-4x)*	2.67	0.68
Em *garden (planted 5x or more)*	1.96	0.59
Mokombai taengbiyp *recent regrowth*	2.68	0.70
Mokombai bol *recent regrowth*	1.29	0.33
Gaimb *'cane grassland'*	3.77	0.75
Obael *'secondary forest'*	3.42	0.69

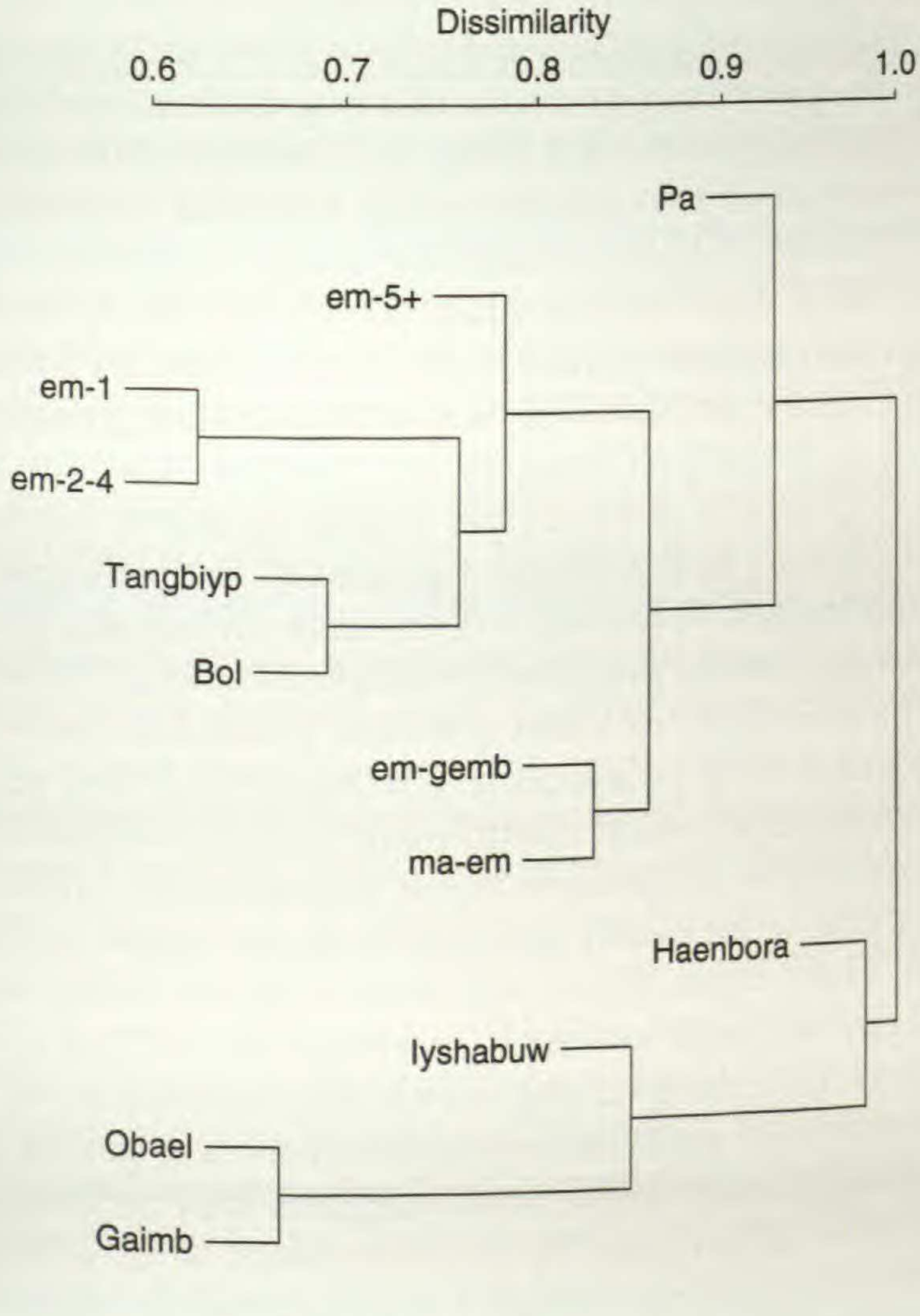
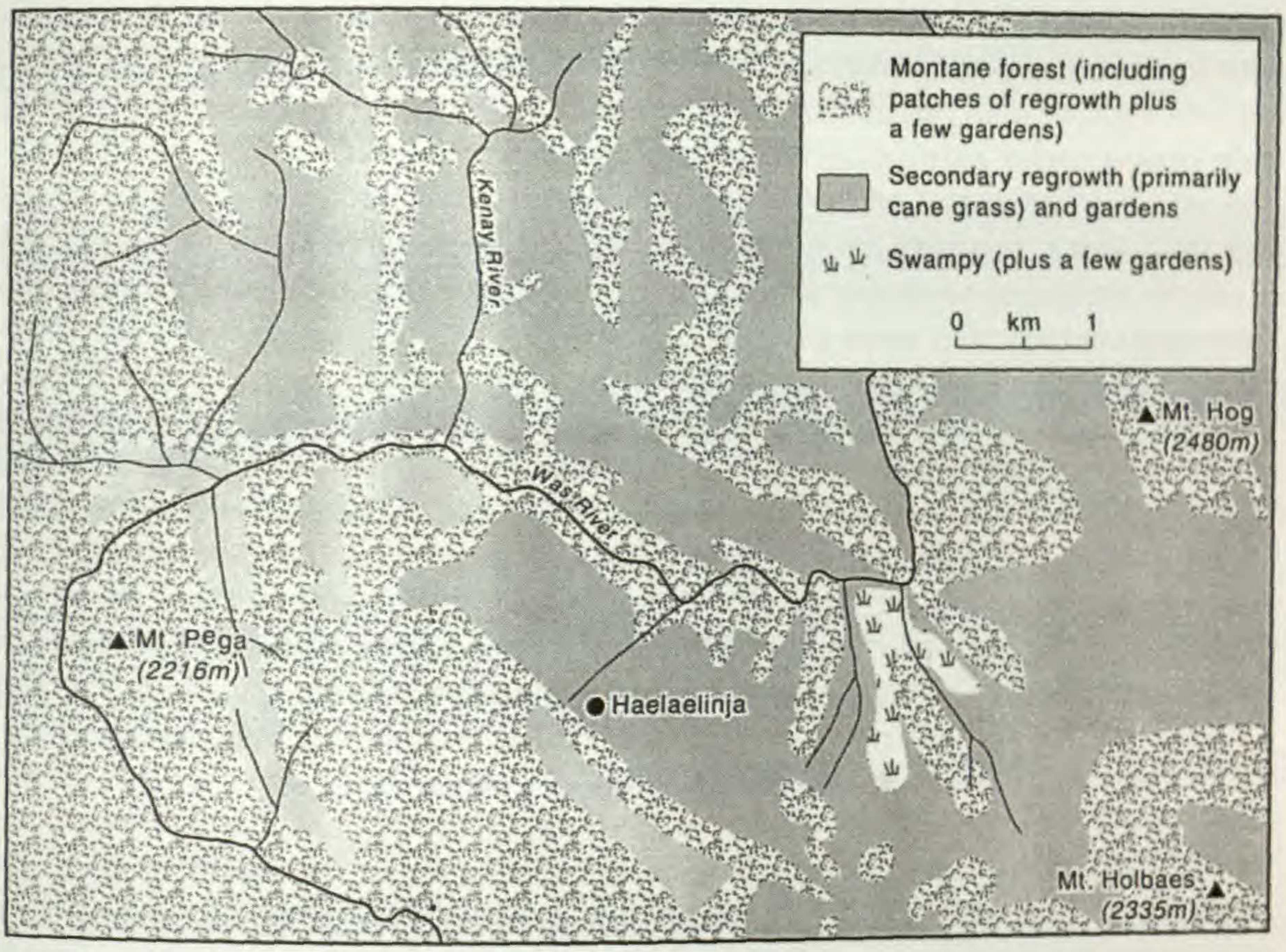


FIGURE 2. — Dendrogram of similarity measures.

lapping substantially (as noted repeatedly by ethnographers for other ethnoscientific domains), we should not allow this to obscure differences. The Wola acquire and apply this knowledge in a more informal and practical way. They know it without needing to identify consciously and count plants. Their categories are also open to negotiation and are not precise. The seral communities pass one into another, as do different virgin communities, with no discontinuous breaks. If people are asked to justify their identification of communities they may disagree, particularly if in a transition phase, for example where soft wooded ***obael*** trees and ***gaimb*** sword grass occur in large numbers, or where a patch of heavily disturbed albeit uncultivated ***iyshabuw*** montane forest supports many plants characteristic of ***obael*** secondary forest.

The ***iyshabuw*** lower montane forest and ***gaimb*** cane grass regrowth are the two vegetational communities that predominate across the Wola region, covering over ninety eight per cent of the area (Map 2). The other communities are small in comparison. These statistics may under–represent the area covered by some of these smaller communities,[6] being calculated from large scale maps and aerial photographs,[7] supplemented by my own limited observations. Detailed work in more restricted areas indicates nonetheless that these overall figures are of the correct order. A sizeable swampy area to the east of the locale of Haelaelinja in the Was valley, covers for example about 0.6 km^2 which, while a noticeable part of the local territory on which it occurs, is too small to show up in a survey of all Wolaland and makes no difference to the percentage given for this vegetational community for the entire region, comprising only 0.02% of it (Map 3).[8] Detailed data on areas under cultivation on the territories of two neighbouring ***semonda*** communities in the Haelaelinja region (population of approximately 300 persons) indicate that they only cover small areas too, 1% of these communities' territories. The local territories in the Was valley region also include considerably larger areas of lower montane rainforest than average, other territories elsewhere have more grassland, swamp, and so on. In his study of LANDSAT imagery for example, Radcliffe (1986:28-29) found that only 39% (125.4 km^2) of the Upper Mendi region is under rainforest, whereas 15% (45.7 km^2) of it is under wetland vegetation,[9] and cane grassland comprises the balance, covering 46% (144.6 km^2) of the area. In summary, while closer study of more limited areas reveals predictable variation between territories across Wolaland, the broad picture is one of forest and cane grassland communities predominating, with patches of other vegetational communities dotted about them.

Whatever the exact developmental relationship between vegetational successions and the long-term extent of montane forest regeneration, Wola subsistence gardening does not appear to be overly destructive of the forest environment, at least in the short-run. Their region has large areas of forest intact regardless of their apparent lack of any manifest conservation ethic; some 52% of their region is under primary forest (the percentage rising to over 80% on less heavily populated territories). And comparison of aerial photographs taken over part of their region by the U.S.A.F. in 1948 with more recent ones suggests that no marked increase has occurred in forest destruction over the last forty years or so. During this time more efficient steel tools have become available, making clearance somewhat easier, and administrative control extended over the area, with the introduction of health services resulting in a spurt of population growth (Radcliffe 1986:29). The dra-



MAP 3. — Map of the vegetation of Aenda and Ebay *semonda* territory.

matic increase in rates of labor migration out of the region over the last decade, on the other hand, suggests that pressure on forest resources is not increasing markedly, and may even decline.

The Wola destroy montane forest, steady population expansion obliging them to clear new land, but they are not indifferent in doing so. Their belief in the presence of demons reveals a tension. Clearance has been gradual and restrained. When they destroy forest to establish new gardens, they usually do so on the fringes of the forest, eating slowly into it from already settled areas. Human activity has already interfered with the forest here, in collecting firewood, raw materials, and so on. It is not where demons reside, they lurk in remoter and less disturbed forested regions. Over many generations, each nibbling away at the forest edges, destruction of large forested areas has occurred. But extensive forested tracts have survived, considering the substantial population density and the great period of time for which agriculture has been practised in the New Guinea Highlands.

The demographic position of the Wola is a critical parameter. Their population density, at some 18/km^2, is relatively low compared to some of the more densely settled regions of the central cordillera of New Guinea — the Enga have around 50/km^2, and the Chimbu and Dani over 100/km^2. The lower population density compared to some other highland regions contributes to large tracts of the Wola montane habitat being relatively well preserved. But it is not just the demographic differences between densely settled central highlanders and the less densely settled Wola that accounts for differences in their regions' vegetational communities. There is more at issue than numbers of people. Cultural factors, such as cultivation practices, even beliefs in demons, may also play a part, as the Maring data suggest (Rappaport 1968; Clarke 1971; Healey 1990). The Maring, who have a slightly higher mean population density than the Wola, have about one-third of their region under anthropogenic vegetation, a substantial part of which is advanced secondary forest and woodland. It appears that the Maring environment and agricultural practices have less profoundly altered vegetation cover and not so significantly deflected successions from reverting back to montane forest. The Wola seem to engender more extensive, longer term transformation of vegetation from forest to stabilized cane grassland.

The Wola cultivate areas under secondary woodland or cane grass far more often than they farm virgin forest sites; for example, only 8% of 293 gardens surveyed in the Was valley were on sites under primary forest before cultivation. It is both supernaturally safer and physically easier to clear secondary regrowth. Also, having only stone tools for most of their history, would have restrained Wola forest clearance. Though over many centuries their ancestors cleared large areas in their main valleys. The natural resource base should not be overlooked. The soil resources of this montane environment are critical, supporting an intensive cultivation regime, which on some sites amounts to a semi-continuous system (Floyd *et al.* 1988). At the population densities involved in the Highlands, other less fertile soils would have led to far more forest destruction, under the resulting extensive shifting agricultural regime. The Wola are not innate conservationists, nor are they wanton destroyers of forest, as depicted by opponents of shifting cultivation (FAO-SIDA 1974; Watters 1971). Their relationship with natural vegetation is more elusive and indeterminate.

NOTES

[1]I particularly thank Wenja Muwiy, Ind Kuwliy and Mayka Haebay for their help in this work, and also Wenja Neleb, for I depended heavily on their knowledge of the plants growing in their region.

[2]Palynological evidence supports this view, indicating that *Nothofagus*, an ancient genus, migrated rapidly to higher elevations in Papua New Guinea as the climate warmed during the Pleistocene, establishing extensive beech forests which other genera then gradually invaded to give today's mixed montane forest (Walker 1970; Hope 1976).

[3]The Shannon index of diversity $H' = \sum_{i=1}^{s} p_i \log_e p_i$ where s = number of species and p_i = proportion of total sample belonging to the ith species. The index of equitability E is calculated from $E = H' / \log_e s$.

[4]The clumps themselves comprise large numbers of individual cane stems, on average 70 green and 43 dead stems per clump, ranging from 20 to 156 green and 12 to 123 dry stems (n=20 clumps, selected by random stone throws).

[5]The cluster analysis uses the following equation as a measure of similarity:

$$(1 / n_{ij}) \sum_{k=1}^{n_{ij}} (| x_{ik} - x_{jk} |) / (x_{ik} - x_{jk})$$

This is a variation on the "Canberra" metric (Digby and Kempton 1987), proposed by D. Wooff, which takes into account not just presence or absence of species but also their relative frequencies. I am grateful to D. Wooff of Durham University's Mathematical Sciences Department for assistance with this similarity measure.

[6]Notably they will omit small-sized areas under some of these less extensive vegetational communities which, occurring in one of the two major communities, are 'lost' because below the minimal size represented at the gross scale of this reconnaissance.

[7]C.S.I.R.O. (1965) Forest Types map; Radcliffe (1986:28); Papua New Guinea 1:100,000 topographic maps; and R.A.A.F. (1959) 1:35,000 aerial photographs.

[8]This swampy area occurs on the territory of a *semonda* neighboring those documented in the right hand column of Table 1 and hence is omitted from the table.

[9]The region surveyed included within it the large Kombie swamp.

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